A Review on Haze Removal Techniques

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Abstract— *This paper represents that picture defogging is usually utilize in lots of outdoor operating systems. The fog removal methods play significant role in various areas of vision processing. Haze detection and elimination is a challenging task for improving the quality of digital images. In general, these images are taken at a long distance from the visual sensor to given scene. Some climatic outcomes such as haze, fog, smoke, dust etc lower the excellence of the received image. The long-term objective of this paper is to show the comparison between different haze removal approaches which illustrate the better quality results.*

Key Words– Haze and dehazing, Dark channel prior, Guided image filter, Bilateral filter.

1. INTRODUCTION

Digital photo is definitely nothing more but 2 dimensional signal. It really is based on numerical operate f(x,y) where x and y are two coordinates horizontally plus vertically. Two dimensional arrays of numbers ranging between 0 to 255, each value represent the individual pixel value. Since taking an picture from the digital camera is an actually physical process. The sunlight is utilized as a supply of energy. A sensor array is useful for the acquiring of the image. To create a digital image, we need to convert details of data into an electronic digital form. This requires sampling and quantization. Digitization is definitely the procedure for changing the images, written text, and even sound by analog marketing in to automated details that will we are able to help to save, arrange, obtain, in addition to reestablish by digital or automated devices. So a digital image is created through the entire process of digitization.

1.1 Haze and Dehazing

Images of outdoor scenes are usually degraded by the atmospheric moisture, dust, smoke, water droplet etc. So these all are the reason to generate air pollution that called Haze. It is an atmospheric occurrence that obscures the quality of the sky resulted by atmospheric dust suspended in the air. The atmospheric particles are within the range below of 1000m. Haze is a mixture of two components Airlight and Direct attenuation. Development of hazy image shown in fig.1. Although taking exterior picture throughout inadequate weather condition, the particular radiance received by simply digital camera from the picture is attenuated alongside the series of sight. The received light is going to mixed with the sunlight coming from the various other guidance known as the atmosphere light. this will bring whiteness in the image. And the second one Attenuation is the gradually reduction in the intensity. For this reason, there is significant decay in the colour. Degree of scattering depends on the range of the scene points from the camera. Image quality is deteriorated due to the existence of substantial particles in the environments which have significant dimension between 1-10 µ m.

Direct attenuation and Air light is described as follow:

$$I(x) = J(x)*t(x) + A*(1-t(x)) \quad (1)$$

Where I (x) is the introduced intensity of the xth pixel, J (x) will be scene radiance vector (the true color which should be recover),A is the atmospheric light, and t is the transmission medium explaining the portion of the light that will not be scattered and reaches direct to the camera. In this equation the one term, J(x)*t(x) is called the direct attenuation; the other term, A*(1-t(x)) is called Airlight.
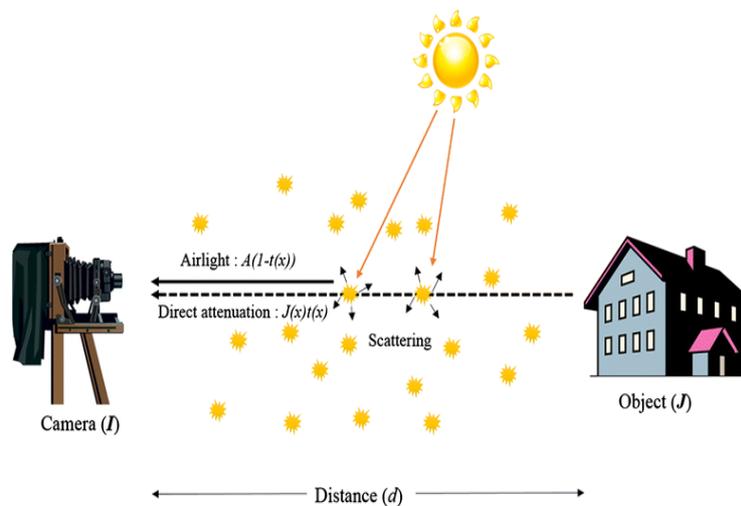
Fig1. Formation of hazy image.

1.2 Dehazing: - In an effort to eliminate this degradation of the picture, numerous haze removal methods are employed which improve the excellence of the image. It is extremely required in client photography and computer perspective vision application. fig2 shows haze and dehaze image. It can be grouped into two categories as described below:-

1. Multiple image dehazing method
2. Single image dehazing method

Fig2. (a)with haze image   (b)Without haze image

1. Multiple image dehazing method:- During this particular haze elimination method, multiple or several images of the same scene will be taken. This process acknowledges well- known variables and avoids the unknowns. This method belongs to the category are discussed below:

a) Method based on different weather condition:-This Specific kind of work use several images obtained from various weather conditions. They consider the differences of two or more pictures of the regarding scene. There are several images which have different properties of the contributing medium. This approach can significantly improve visibility, but its drawback is to wait until the properties of the medium change. So, this procedure is not able to provide the results instantly for scenes that have never been satisfy before. Moreover, this process also cannot handle powerful scenes.

b) Method based on polarization:-Polarization-based dehazing technique is the major part of the multi-image group taken with two differently polarized filters. They usually use two input images, one after another, to produce one dehaze image. 'Air light is partially polarized' and the direct transmission of the object is un-polarized. To remove haze, at least two images with different polarization filter states are necessary.

c) Depth map based method:-This approach uses depth details for haze removal. It runs on a individual image and presumes that 3D geometrical model of the scene is given by some databases for example from Google Maps and also assumes the texture of the scene is given. This 3D model then line up along with hazy image and offer the scene depth. It does not need specific

equipment's. It is not automatic and it needs user Interactions. This process utilizes some amount of interactive adjustment to dehaze image.

2. Single image dehazing method:- It relies upon statistical assumption to recovers the scene information based on the proceeding information from a single image. The various methods classified are explained as follows:-

a) Contrast maximization method: **-** Eliminating the haze will improve the contrast of the image. Because haze diminishes contrast. But, the resulting images have larger saturation values because this method doesn't physically enhance the brightness or depth but somehow just enhance the visibility. Moreover, the result contains halo effects at depth discontinuities.

b) Antistrophic diffusion: - It is an actual method that minimizes haze from image without removing important parts such as edges, lines or other details which are useful for the knowing of an image. Its versatility combine smoothing properties with image enhancement qualities. An algorithm used for anisotropic diffusion for refining air light map from dark channel prior. It is used to smooth the air light map and It performs very well in heavy fog.

c) Atmospheric light: - It is calculated by dark channel prior with a fixed size window. If the minimum filtering is done using too small window, then it may pick up extra light sources in the image, which can corrupt the estimation. When using a window size of 15 in image, the atmospheric light will be corrupted and if it increased to 31, the atmospheric light will be properly estimated amongst the pixels. The development of an essential interactive process is needed to avoid making a poor guess of the atmospheric light.

1.3 Existing technique used

1. Dark Channel Prior:

This technique is actually useful for single image dehazing. It is used to measure the statistics of the outdoor fog free image. Imagine that there are few pixels having very minimal intensity in any one of the colour channel. These pixels are called dark pixels. These dark pixels are used to calculate the transmission map. Transmission map is used to eliminate some blocky effect. Single image is utilized for restoration of foggy image so that Transmission map is estimated accurately. Basically, the minimum intensity in such a patch need to have very minimum value.

Dark channel is calculated by,

$$dark(x) = \min_{y \in \Omega(x)} \{ \min_{c \in \{r,g,b\}} \{ J^c(y) \} \},$$

Where J' is a color channel of J and Q(x) is a local

patch centered at x. Our observation says that except for the sky region, the intensity of Jdark is low and tends to be zero, if J is a haze-free outdoor image. We can say Jdark the dark channel of J, and we call the above statistical observation or knowledge the dark channel prior. Both transmission t and atmospheric light A can be obtained by the DCP based method. After a refinement on transmission, which is discontinuous because of the two discrete minimum operations, the scene radiance can be recovered from,

$$J(x) = \frac{I(x) - A}{\max\{ t(x), t_0 \}} + A$$

where t_0, is a lower bound which has typical value 0.1, which introduced to make this algorithm more robust to noise. The low intensities in the dark channel are actually due to shadows or colorful objects. Based on the DCP, the dehazing is accomplished through four major steps: atmospheric light estimation, transmission map estimation, transmission map refinement, and image reconstruction. These are explained below:-

a) Atmospheric light estimation is calculated by using dark channel prior with fixed patch size.

b) Transmission map estimation:-

Estimated transmission map from input haze image is roughly good.It contains some blocky effect because transmission is not always constant in a patch..We can use soft matting algorithm for refine transmission.

c) Transmission map refinement:-it is done by using method Gaussian filter, bilateral filter.

d) Image restoration:-In this step, the value of image is restored. The value of t0 is range from 0.1 to 0.75 in order to make result satisfy the demand of SNR.

2. FUSION BASED DEHAZING

This type of method uses only the inputs and weights derived by original hazy image. The primary concept is to merge many input images into single one, keeping only the most significant features of them. It needs several images of the same scene. Due to high complication of time to remove haze, multiple image dehazing technique used that takes lesser time and just a single image per scene. This method work by using three steps to remove haze.Step1: Generation of two input images from original.Step2: Defining weight measures.Step3: Fusion of inputs and weight measures. All three are explained below:-

Step 1.Definition of Inputs: fusion based dehazing technique requires number of advices resulting from first image. The first input is received simply by undertaking white balance operation White balancing is most crucial stage which aims to enhance the image appearance by discarding undesired color cards, due to number of illuminations. The 2nd input is chosen to boost contrast in those region which are suffering because of airlight influence. Now it has been observed that this step is significantly amplify the visibility in hazy parts well as fine details of picture gets get destroy. Thus, so as to remove the following degradation suitable weight maps are usually defined for every suggestions..

Step2. Weight Measures:- This derived inputs tend to be proper measured through some weight maps. All these type of weight map try to help preserve the region along with great visibility. The Luminance weight map calculate visibility of every pixel. The idea provide high value with great visibilty as well as rest. It is viewed that this weight map cut down global contrast as well as color details .So as to overcome this problem 2 weight map added that are chromatic map (color information) as well as saliency map (global contrast).The Chromatic weight map is actually created to control saturation gain around end resultant image. This particular weight map was designed to evaluate distance between amongst it is saturation and maximum involving saturation range. The Saliency weight map discovers how much conspicuousness based on the community areas.

Step3. Multi-Scale In practice, every input is decomposed into pyramid by applying Laplacian operator at different scales. Laplacian pyramid of image is produce by applying band pass filter followed by down sampling operation. As a band pass filter, pyramid construction tends to improve image features like edges, which plays most important role. every stage in Laplacian pyramid represents the difference between successive levels of Gaussian pyramid. Likewise, for each normalized weight map Gaussian pyramid is calculated. The Gaussian pyramid is a series or collection of images obtained by applying low pass filter followed by down sampling operation.

3.FILTERING BASED DEHAZING

1. Bilateral Filter The bilateral filter calculates the output pixel as a weighted average of neighboring pixels. It smoothes image as well as preserve edges. Because of this quality it is widely used in noise reduction, HDR compression. It is generalized to the joint bilateral filter in which the weights are computed from another guidance image rather than the filter input. However, it has been noticed that the bilateral filter may have the gradient reversal artifacts in detail decomposition and HDR compression. The reason is that when a pixel has few similar pixels around it, the Gaussian weighted average is unstable. Another problem in the bilateral filter is its efficiency.

3. Optimization based image filtering:- A good solution optimizes a quadratic cost function and resolves a linear system, which is equal to implicitly filtering an image by an inverse matrix. In image segmentation and colorization , the affinities of this matrix are Gaussian functions of the color similarities. In image matting, a Laplacian matrix is made to enforce the alpha matte as a local linear transform of the image colors. This matrix is also able to remove haze. The weighted least squares (WLS) filter is used to adjust the matrix affinities according to the image gradients and generates a halo-free decomposition of the input image. This method usually generate results closely related to the explicit filters good quality value but to calculate the corresponding linear system are time-consuming. It has been found that these kind of filters are very closely related to explicit filter.

4. Guided Image Filter A general linear translation-variant filtering process, which involved a guidance image I, an filtering input image p, and an output image q. The filtering output at a pixel I was expressed as :-

Weighted average: q_i = Wij I p_j

j where i and j were pixel indexes. The filter kernel Wij was a function of the guidance image I and independent of p. This filter was linear with respect to p. The guided filter was a local linear model between the guidance I and the filtering output q. We assumed that q was a linear transform of I in a window!k centered at the pixel k: q_i = $a_k I_i$ + b_k,$\forall$ i € wk where (a_k,b_k) were some linear coefficients assumed to be constant in wk. A square window of a radius r was used. This local linear model ensures that q has an edge only if I had an edge, because $\nabla q = a \nabla I$. The output q was modeled as the input p subtracting some unwanted components n like noise/textures: q_i = p_i – n_i.

Wiener Filtering

 Wiener filtering is drawn on dark channel prior method which is used to calculate the issues such as color distortion and halo effect in final output image. The, median filtering is needed to preserve edges and combined with wiener filtering by image restoration problem which is again converted into optimization problem. The fourier transform of the "ideal" version of a given image, and the blurring function are taken into consideration. The best method to solve the problem of original pictures containing noise is by using Wiener filtering. This technique is used to recover the contrast of a large white area for image because the running time of the algorithm is also less.

4. COLOUR ATTENUATION PRIOR

Colour attenuation prior may be depend upon difference between the brightness and the saturation of the pixels within the hazy image. It repairs transmission map and restores visibility.By developing a linear model for modeling the scene depth of the hazy image and learning the parameters of the model by using a supervised learning method, the depth information details can be recovered easily .There is a need to select most sensitive features which make changes in image quality. The main and important task is to remove haze by depth map estimation. The advantages of this prior are as follows:-

• This easy and powerful method can help to develop a linear model for the scene depth of hazy image.
 • The bridge between the hazy image and its corresponding depth map is built e actively.
 • With the generated depth details, it will be easy to remove the haze from the single picture. If the information about the scene structure available is less, it will be very difficult to detect the haze from a distinct image in computer vision.

2. LITERATURE SURVEY

Tang X, et al. (2013) [1] regarding massive hurdle from the visibility applications. Many researchers have handled various offered methods to boost a lucidity, visibility in the obscure photograph, generally handled saturation along with brightness. Caused by haziness, a graphic normally dropped coloration along with edges, consequently dehazing/ haze elimination technique reestablishes borders loss along with coloration affects badly. To enhance the quality of a graphic (hazy) various details are necessary for digesting to get the top-quality computer eye-sight apps Rahul singh, et al. (2015) [2]Photo processing is usually an rising technological know-how along with graphic is usually utilised in numerous grounds such as healthcare along with education. Photo might virus ridden because of the noise. To remove this disturbance, procedures and other filters are usually used. In this newspaper, numerous engineering in addition to their filters for you to recognize and take off a disturbance are usually outlined. Bingquan Huo,et al. (2015)[3]the item offered the open-air photos taken throughout rainy climate are changed as a result of arsenic intoxication errors, haze, weather and so on. Images with displays taken throughout undesirable climate get very poor differences and colors. Resulting from errors you will find there's issues to several computer system eye-sight programs as it reduces the actual awareness from the scene. This specific report provides a report regarding enhancement regarding comparison, visible vary and coloration fidelity. X. Tang, et al. (2011) [4] discussed about large hurdle in the presence applications. Many scientific study has handled several suggested procedures to improve your clearness, presence from the fuzzy image, typically handled saturation in addition to brightness. On account of haziness, an image normally misplaced coloring in addition to ends, so dehazing/ haze removals approach reestablishes advantage cutbacks in addition to coloring has an effect on badly.By using polarization, RETINEX dependent technique etc. dehazing have been simpler. To further improve the caliber of an image (hazy) the several details tend to be meant for control to have the remarkable computer eye-sight apps..FATTAL, R, et al. (2007) [5] current a brand new way for pricing the particular eye sign in hazy views presented an individual input image. Determined by this particular evaluation, the particular dispersed gentle is actually taken out to increase scene awareness as well as recuperate haze-free scene contrasts. During this brand-new technique we prepare a sophisticated graphic creation type that is the reason for work surface shade providing besides the sign function. Results prove the modern technique skills to eradicate the particular haze stratum and provide a efficient sign estimate. Ullah, E., R. Nawaz, et al. (2013) [6]. offers suggested gifts a critique in various errors elimination techniques. Haze delivers difficulties to several computer system vision/graphics apps simply because it decreases this presence in the scene. Haze is because of the a couple of fundamental phenomena some may be attenuation as well as some other is usually air light. Attenuation cuts down on distinction and also air light-weight increases the whiteness inside the scene. Haze elimination tactics retrieve the color and also distinction in the scene.The actual aim in this newspaper is usually look around the various strategies for efficiently taking off the errors coming from electronic graphicsS. Te-Jen, L, et al. (2008) [7] give Picture advancement is targeted to increase picture superior through making the most of the knowledge content material inside enter image. In this article a new particle travel optimisation (PSO) based skin tone preserving coloration picture advancement method is proposed.This expertise of the strength picture is improved using a parameterized change for better perform, where details will be improved through PSO based upon an ambition function. Sonam, Rajiv Dahiya , et al.(2015)[8] this provides each histogram equalization solutions which could become used for a difference improvement purpose. The item endeavors

lowering of the volume of dull levels. Form a contrast improvement by means of histogram equalization process include applying regarding dull levels judging by changeover purpose that will comes from a probability submission regarding dull levels baked into feedback image.It evaluate different histogram equalization approaches conserving impression lighting as well as the difference improvement can be presented. The real key method for this particular purpose is with impression segmentation. Ms. Ghorpade,et al.(2014)[9] offers handle Photo dehazing is essentially the most vital study place inside photograph producing in addition to structure analysis. It will be the mixture of oxygen lighting in addition to attenuation process. Atmosphere lighting enhances the whiteness of the photograph in addition to attenuation consequence decreases the contrast. Haze eradication algorithms are usually important in many eye sight applications. That researched several haze eradication algorithms used for the purpose of dehazing operation inside photograph producing programs. Y Song, H Luo,et al.(2015)[10]talked about the removing of errors called dehazing. This is completed in the actual physical wreckage product, which necessitates an alternative of the ill-posed inverse problem. To relief the impossibility of the inverse trouble, a new novel prior called dim route prior (DCP) ended up being not too long ago proposed. The actual DCP comes from the sign of healthy out of doors images the fact that depth price of no less than one color route with a nearby window is actually close to zero. Based on the DCP, the dehazing is actually reached via some big actions: atmospheric gentle evaluation, transmitting plan evaluation, transmitting plan accomplishment, as well as graphic reconstruction.

3. COMPARISON TABLE

Table 1: Comparison of various haze removal techniques

S.NO.	Author Name	Year	Technique	Feature	Limitation
1	Zhu Q etal.	2015	Genetic algorithm-based parameter selection approach	Parameters may be adaptively and automatically adjusted	CNC index may not be the good one to measure image defogging effect
2	Ms. Ghorpade etal.	2015	Improved Atmospheric Light Estimation	Textures and edges of the processed images are enhanced	Not for real-time processing
3	Sonam, Rajiv Dahiya,etal.	2015	An improved High-Boost Filtering Algorithm	Nicely enhances the visibility of sea fog image	Noise exist
4	Bingquan Huo.etal.	2015	Color Attenuation Prior	Restore the scene radiance via the atmospheric scattering model, and effectively remove the haze from a single image.	High execution time
5	Rahul singh etal.	2015	Dark channel prior integrated with Gradient prior law	Improve the visibility and keep the details of image	Not suitable to surveillance and some unmanned vehicle systems
6	Atul Gujral,etal.	2014	Haziness Analysis	No user interaction is needed and the computing speed is relatively fast	Not dealing effectively with an object without a clear shape
7	Tang X,etal.	2013	Markov random field	Provides good restoration value with respect to visibility and contrast	Textures in the scene are the critical element

8	Ullah, E.,etal.	2013	Adaptive Wiener Filter	Faster than existing fast single image dehazing methods	Not for real-time uncompressed, video processing
9	Kaiming He,etal.	2011	Variation framework	Effectively removes haze from long distance regions.	Not able to estimate 3D structure in the scene
10	Y Song etal.	2011	simple and adaptive single image dehazing algorithm	maximize the contrast of the output image	High computational complexity analysis
11	He K ,etal.	2010	statistical framework based on the mixture of gaussian	improve the safety and the traffic flow control	Not analyses of rain and hail

4. GAPS IN LITERATURE

Haze removal algorithms become more beneficial for various vision applications. It has been originated for the most existing research which have mistreated numerous subjects. Following are the various research gaps concluded using the literature survey:-

1. The presented methods have neglected the evolutionary techniques i.e. Ant colony optimization, particle swarm optimization algorithm or fuzzy logic kind of techniques to improve the quality of the Haze removal algorithms.
2. The restoration level t^0 has taken statically i.e. 0.1 in most of existing techniques.
3. The particle swarm optimization suffers from poor convergence speed.

5. CONCLUSION

In this paper we have discussed the image haze removal techniques which play a significant role in several regions of vision processing. Many real-time applications suffer with poor contrast problem because of haze or fog. Some environmental effects for example haze, fog, smoke, dust etc, effect very poorly the quality of the received picture. Image haze removal techniques have taken restoration value statically, that depends upon the given set of images that limits the performance of fog removal method as restoration. This value needs to be adaptive as effect of haze on given image varies scene to scene and atmospheric veil. The presented methods have neglected the use of multi-objective optimization techniques to improve the adaptivity of the digital haze removal algorithms. So, in future, we will propose multi-objective Differential Evolution based optimization for image defogging using contrast gain and percentage of saturated pixels.

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